NANO STRUCTURED ARSENIC SORBENT

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BACKGROUND

- Argonide manufactures nanopowders including a nano alumina fiber 2 nanometers in diameter (NanoCeram^{R})

  The fiber is highly electropositive
- NanoCeram filters consist of the nano alumina and microglass fibers – They received the Hall of Fame Award for 2005 from the Space Foundation
- The filters retain most colloidal and sub-micron particles
- They will remove virus, bacteria and cysts to >99.9999% and at flowrates several hundred times greater than an ultraporous membrane
- Pleated filters are being sold for industrial and certain drinking water applications
- They can be used in various arsenic removal processes such as filtering colloidal silica and in coagulation-filtration

ACTIVE PROGRAMS

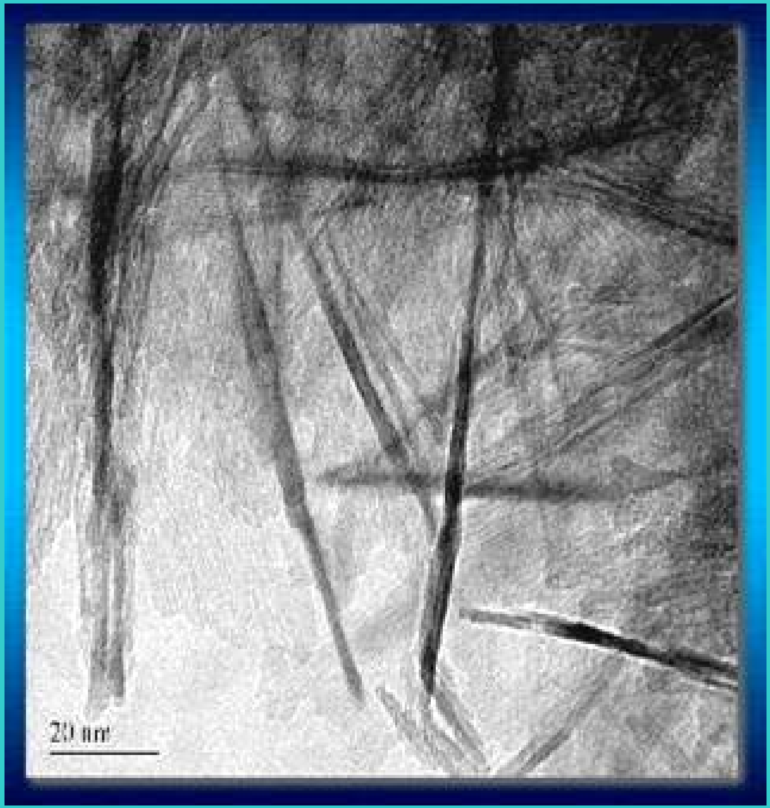
- USAF SBIR (Phase I) – Develop a HEPA filter
- DOE CRADA – 5 year Program completed in Aug. 2005)- In collaboration with NREL, support Russian institutes to Develop Arsenic POU filter
- DTRA Subcontract - Demonstrate enrichment of pathogens in water for BW detection purposes
- In house- Develop POU cartridge “Bio” filter, a village well filter and a portable for campers, backpackers and military

TEM Image

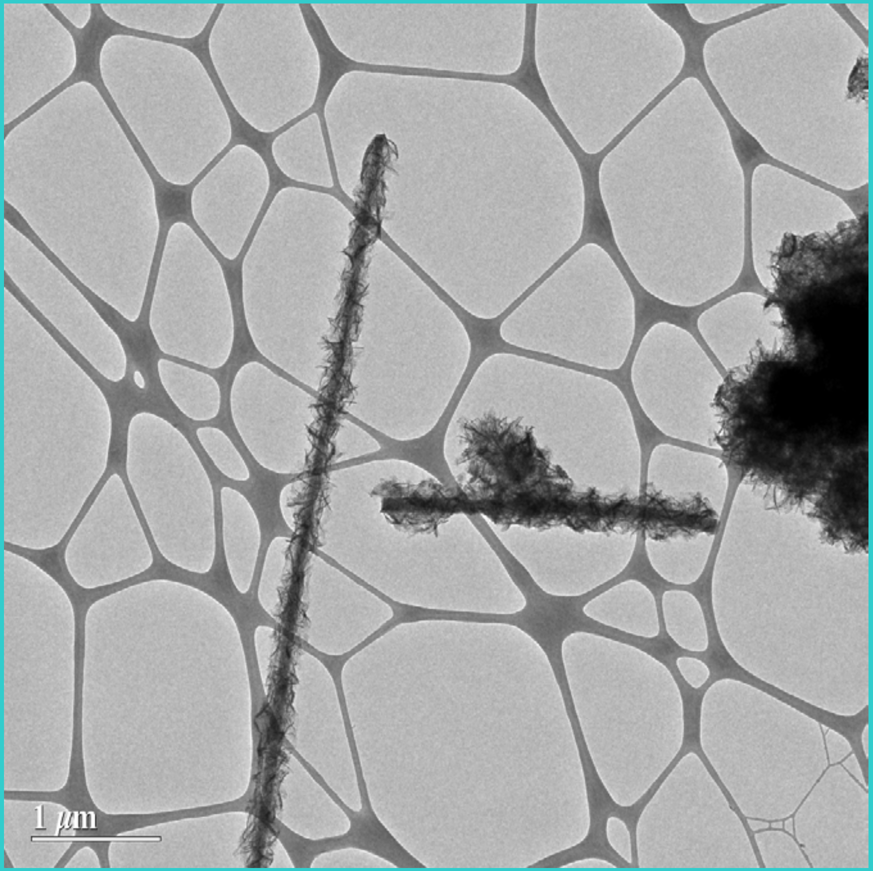
The active ingredient of our filter is an alumina (AlOOH) fiber, only 2 nanometers in diameter. The nano fibers are highly electropositive.

They are smaller than a carbon nanotube or a DNA molecule

Made into a paper type of filter using cellulose, polymer and glass fibers



NANOCERAM ON MICROGLASS FIBERS



Pilot Lot Of Nanoceram® Media

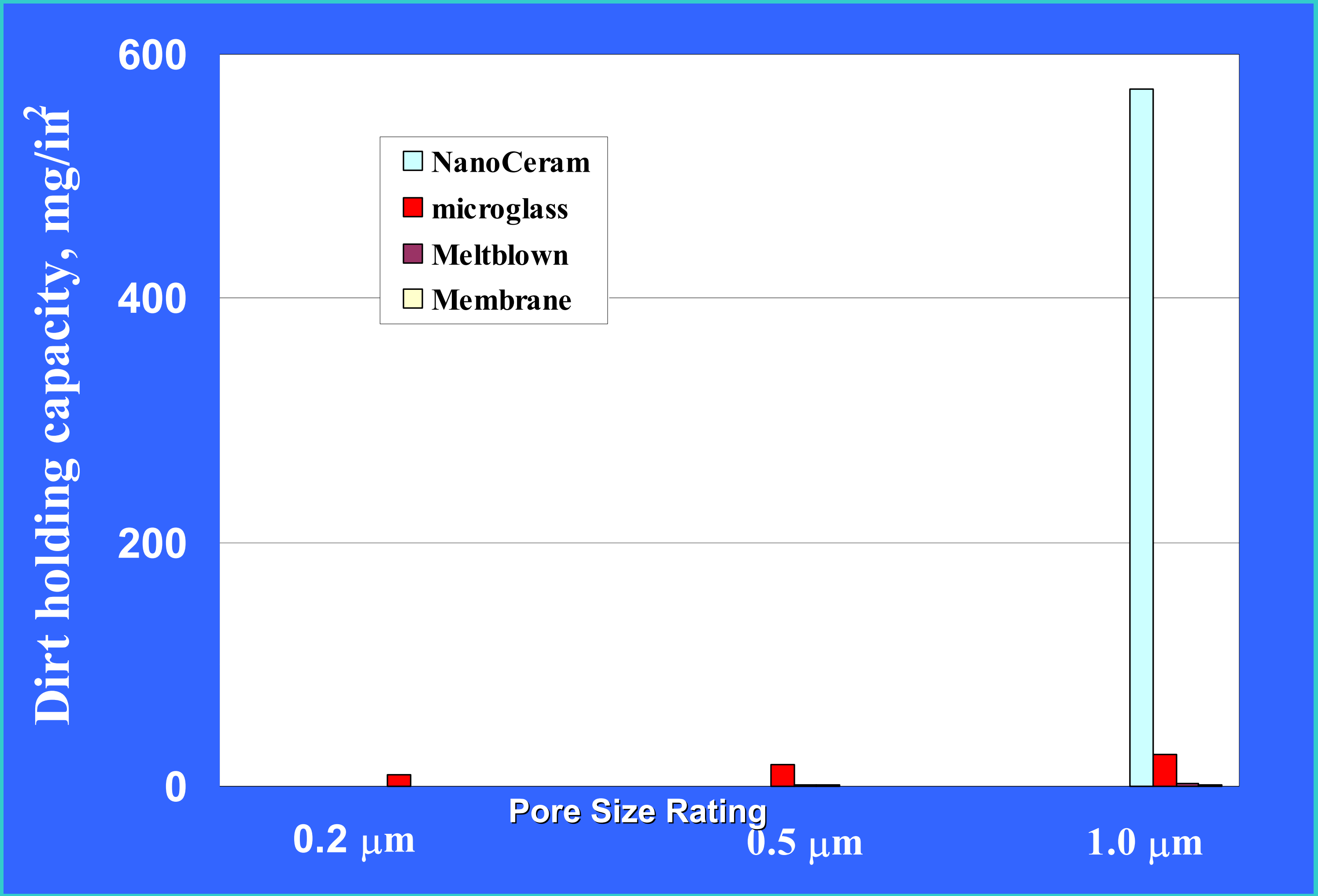
A major cost barrier was overcome when we produced our media at a paper mill

Zeta Potential & Virus Removal

NanoCeram® Wt % on Supporting Fiber	Potential, mV	Virus Retention (%)
0	-35	8
5	-10	29
10	7	94
15	12	>99.9999
25	32	>99.9999
40	29	>99.9999
50	23	>99.9999

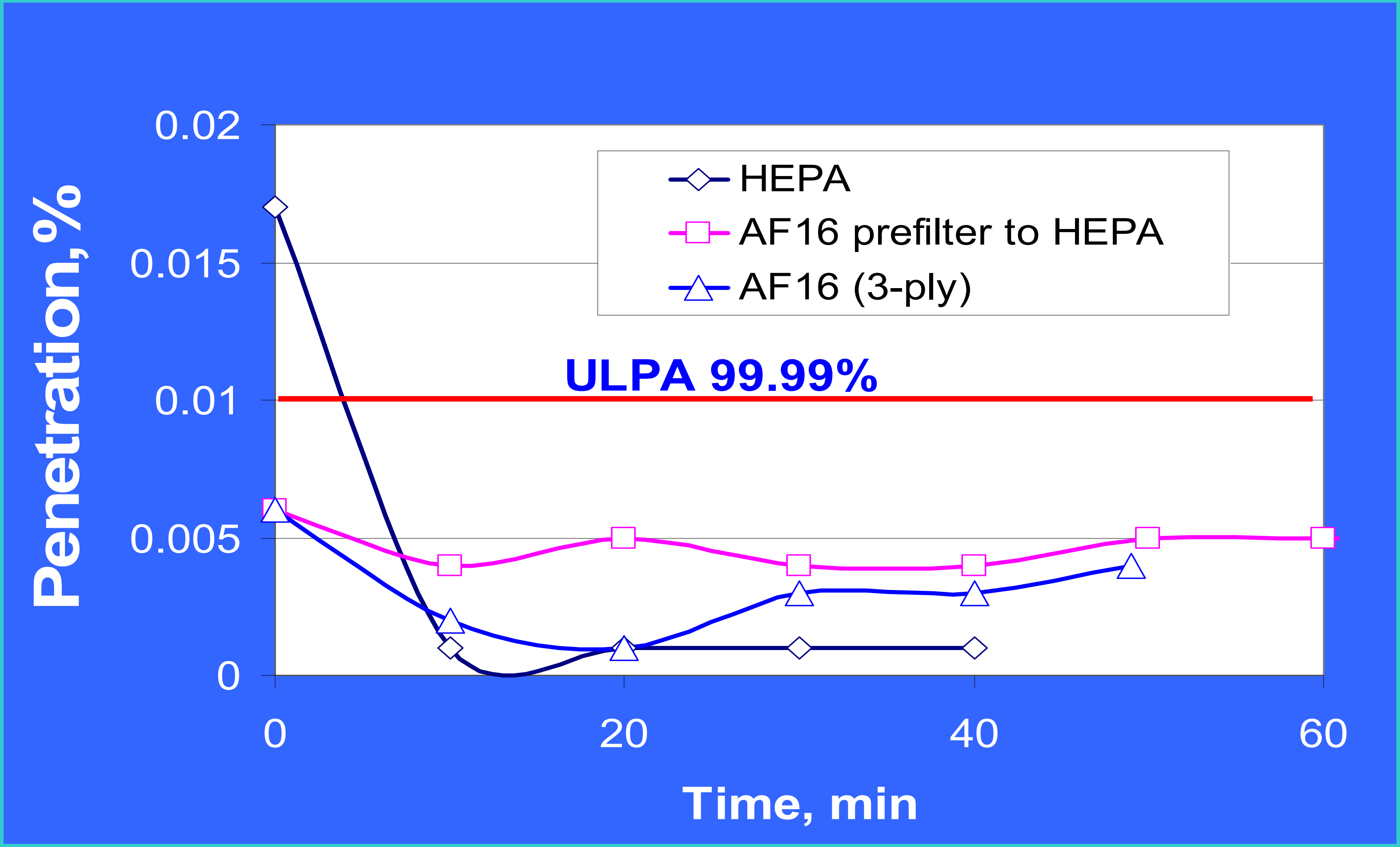
Zeta potential becomes positive with increasing nano alumina and this causes a marked increase in virus (MS2) retention

Filtering Dirt Particles (A2 Fine Test Dust)



Dirt holding capacity (life) is ~ twenty times greater than microglass filter media and 300 times greater than either meltblown or membrane media.

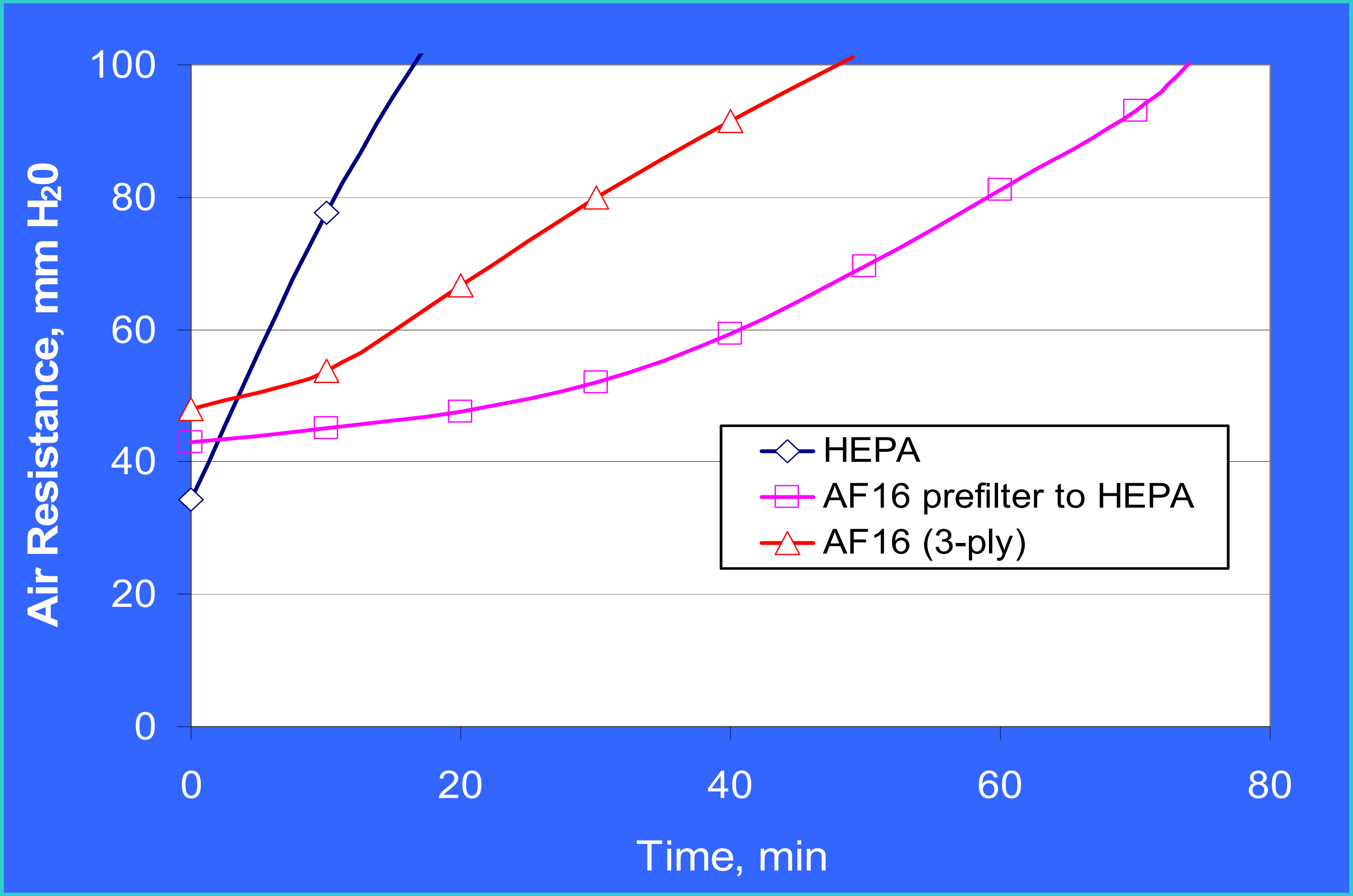
NaCl Aerosol (0.3 μ) penetration



We can improve on HEPA two ways, by direct substitution or by using NanoCeram media as a prefilter

ΔP Increase (Life) of Air Filter Media

(when challenged by 0.3 μ NaCl aerosols)

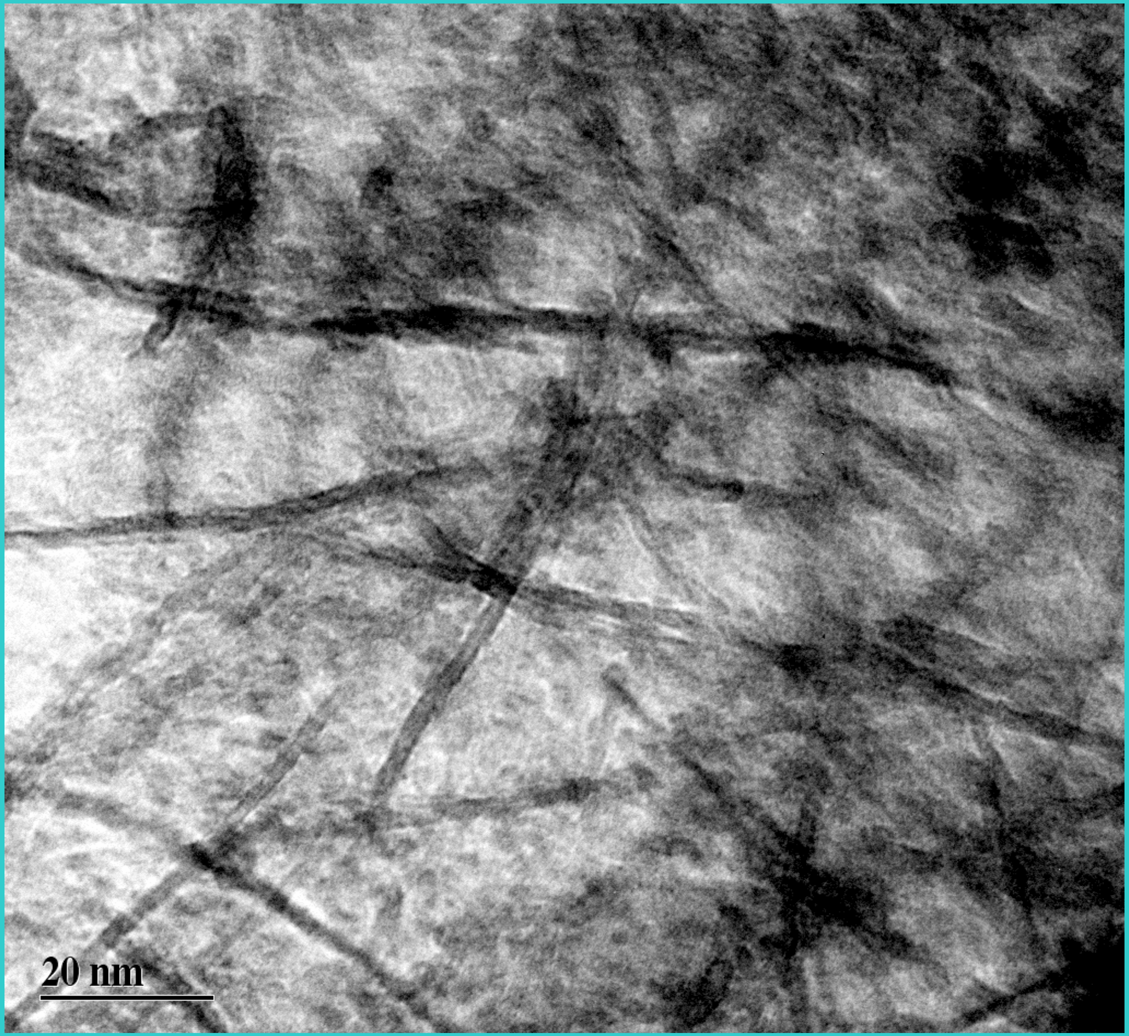


The life under load of NanoCeram (AF 16) is much greater than HEPA. But using a single layer as a prefilter for HEPA is better.

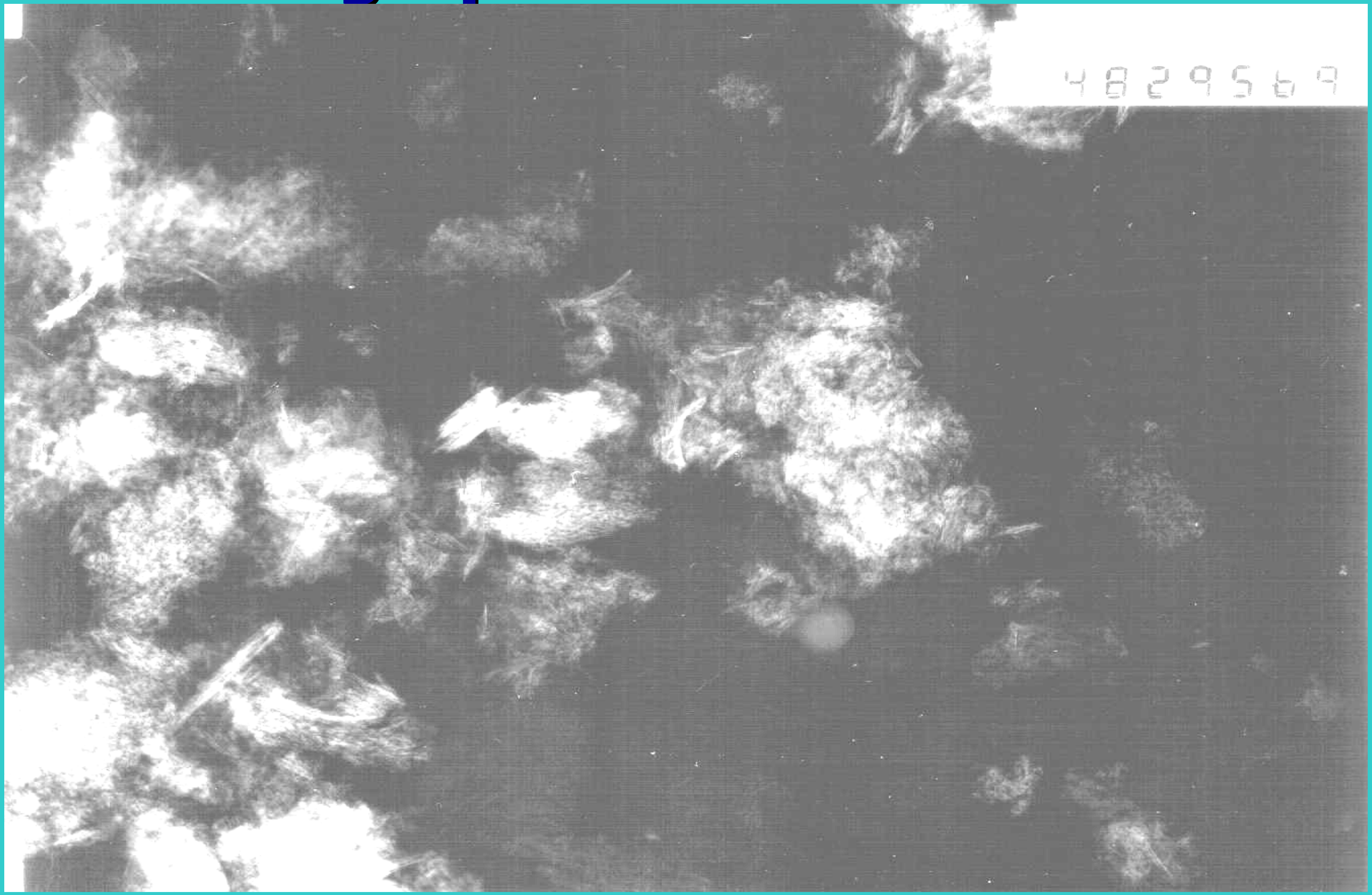
PROGRAM APPROACH – ARSENIC FILTER

- Initial effort to use non-woven resulted in low volumetric capacity so developed granular media
- Primary Goal- Develop sorbent for As III and V from 300, 50 to <10 ppb @ pH 6.5 and 8.5 in a POU
- Steps: Optimize on equilibrium As capacity
- Determine dynamic capacity in short beds
- Determine dynamic capacity in deep beds
- Develop a useful model
- Benchmark vs. other arsenic sorbents

TEM of Alfox-18 Sorbent



TEM Micrograph of Alfox-GR3 Sorbent



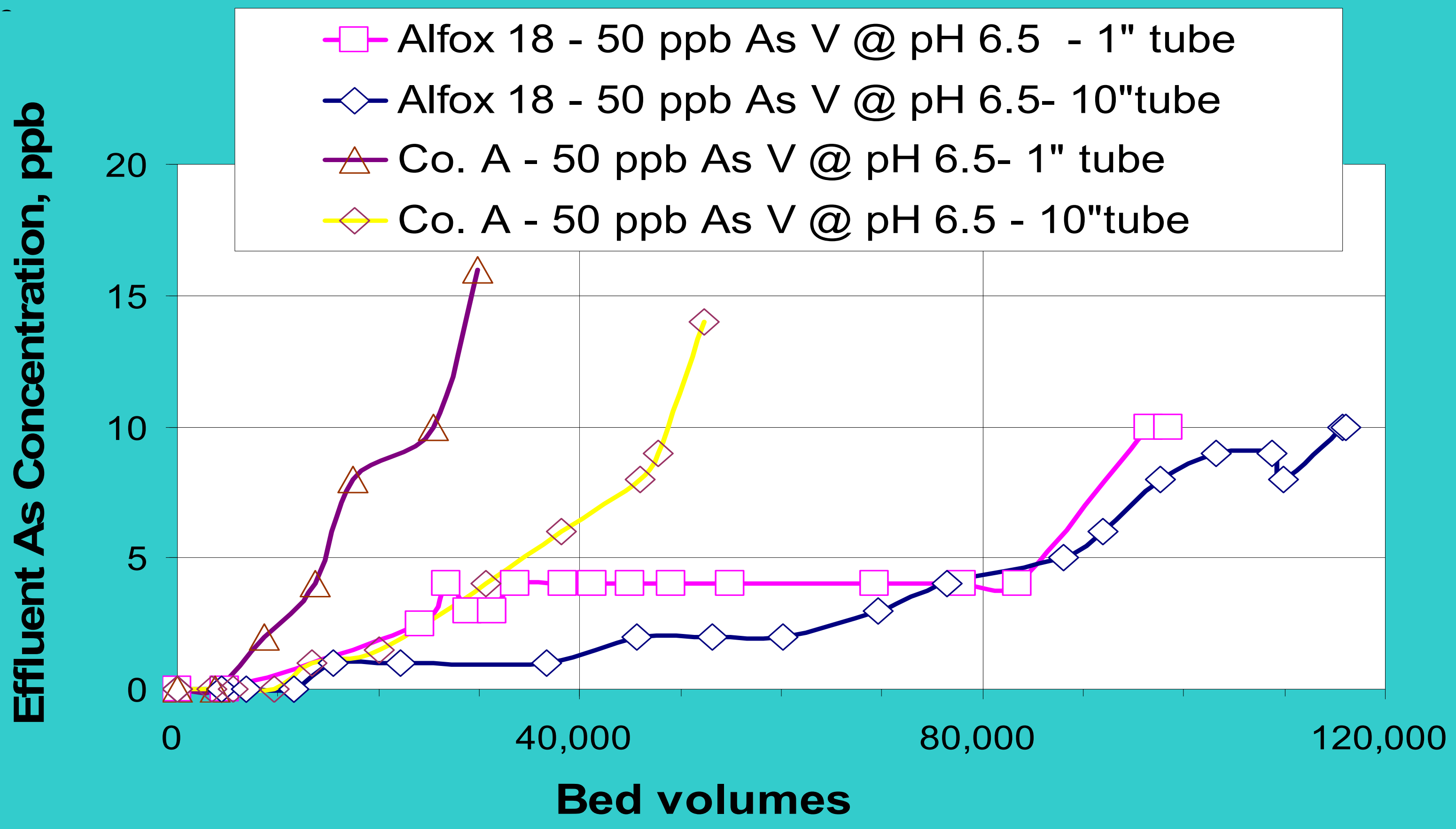
AlOOH fibrils 4 to 7 nm diameter and lengths from 50 - 100 nm

Test methods: Dynamic capacity

- Several types of test methods were used for characterizing sorbents.
- A full size bed (10"long), operating at the flow velocity that would exist in the POU filter.
- A second test was used to reduce volume of solution, while allowing us to manifold the beds so we could test a number of filters simultaneously. It consisted of a 1" long bed challenged at 1/10th actual flow velocity in a similar test duration as a full length bed
- The 1" tube test was also operated to higher effluent concentrations (50% of influent and full exhaustion) for the purposes of modeling

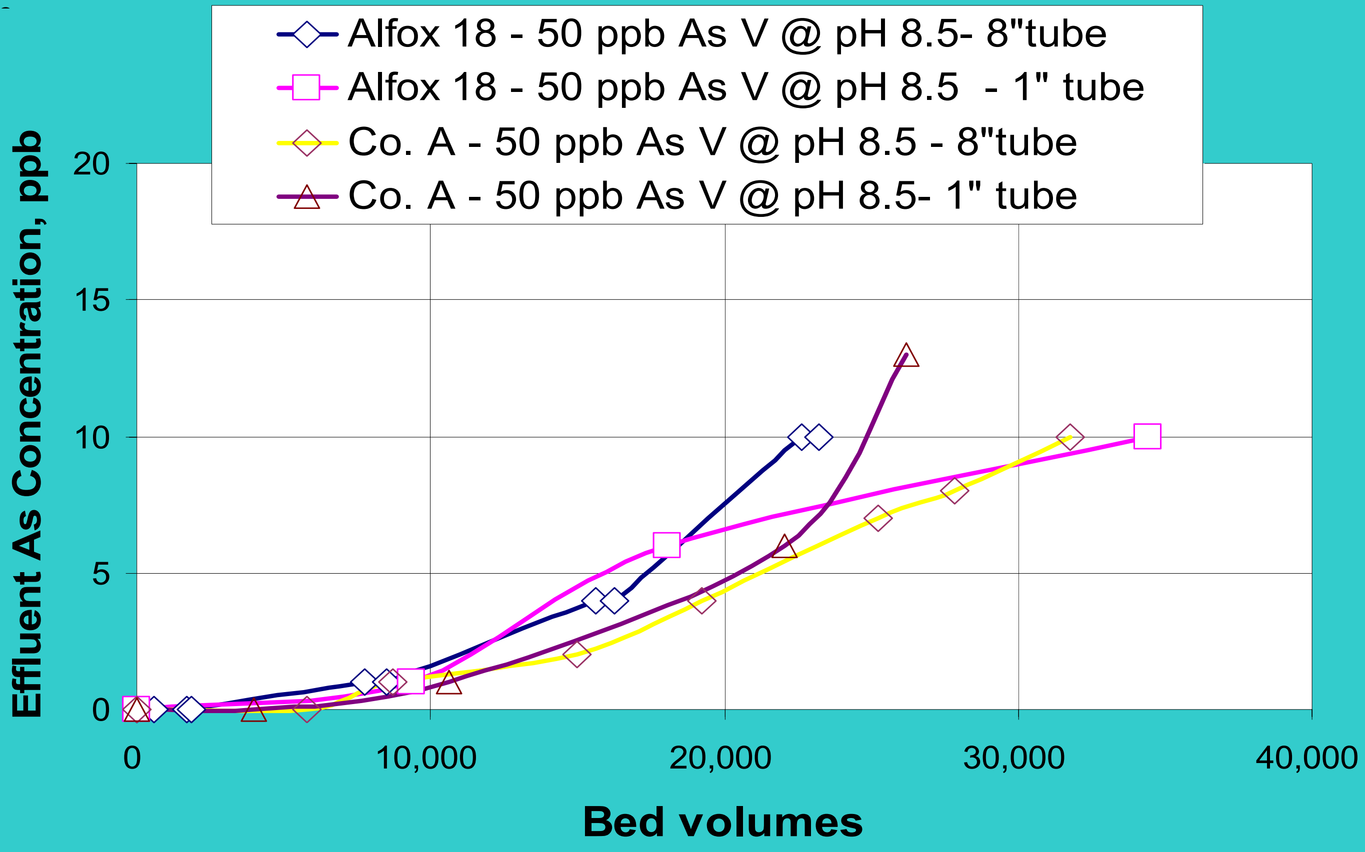
ADSORPTION AS FUNCTION OF BED DEPTH @ pH 6.5

(1", 10" Beds, simulated flow of 1 gpm)



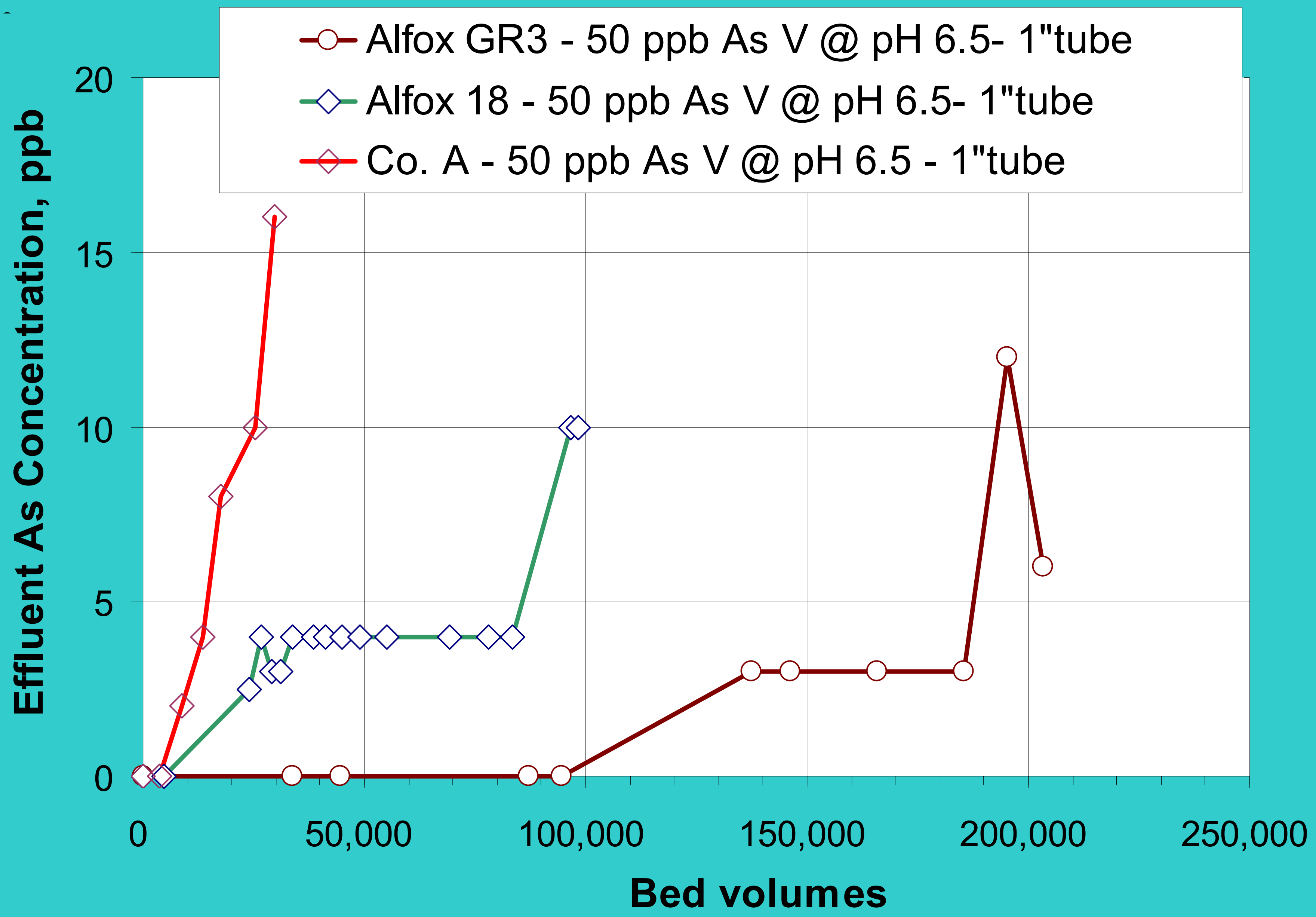
These results verify that the rapid short tube test is in reasonable agreement with longer tube tests.

Adsorption vs. Bed Depth @ pH 8.5
(1" and 8" beds –simulated flow of 1 gpm)

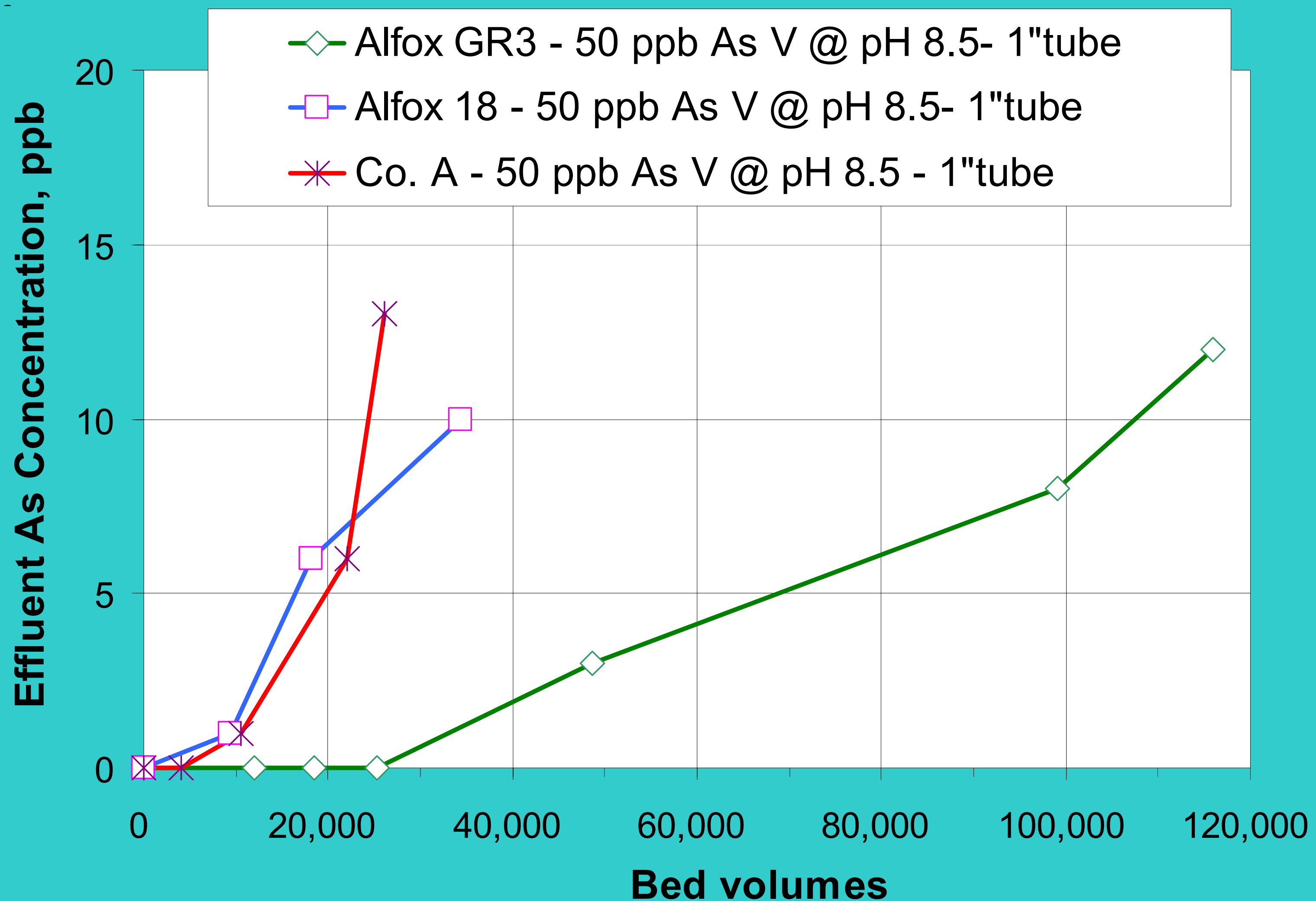


These results also verify that the short tube test is in reasonable agreement with longer tube tests.

Dynamic Adsorption of 50 ppb As V @ pH6.5

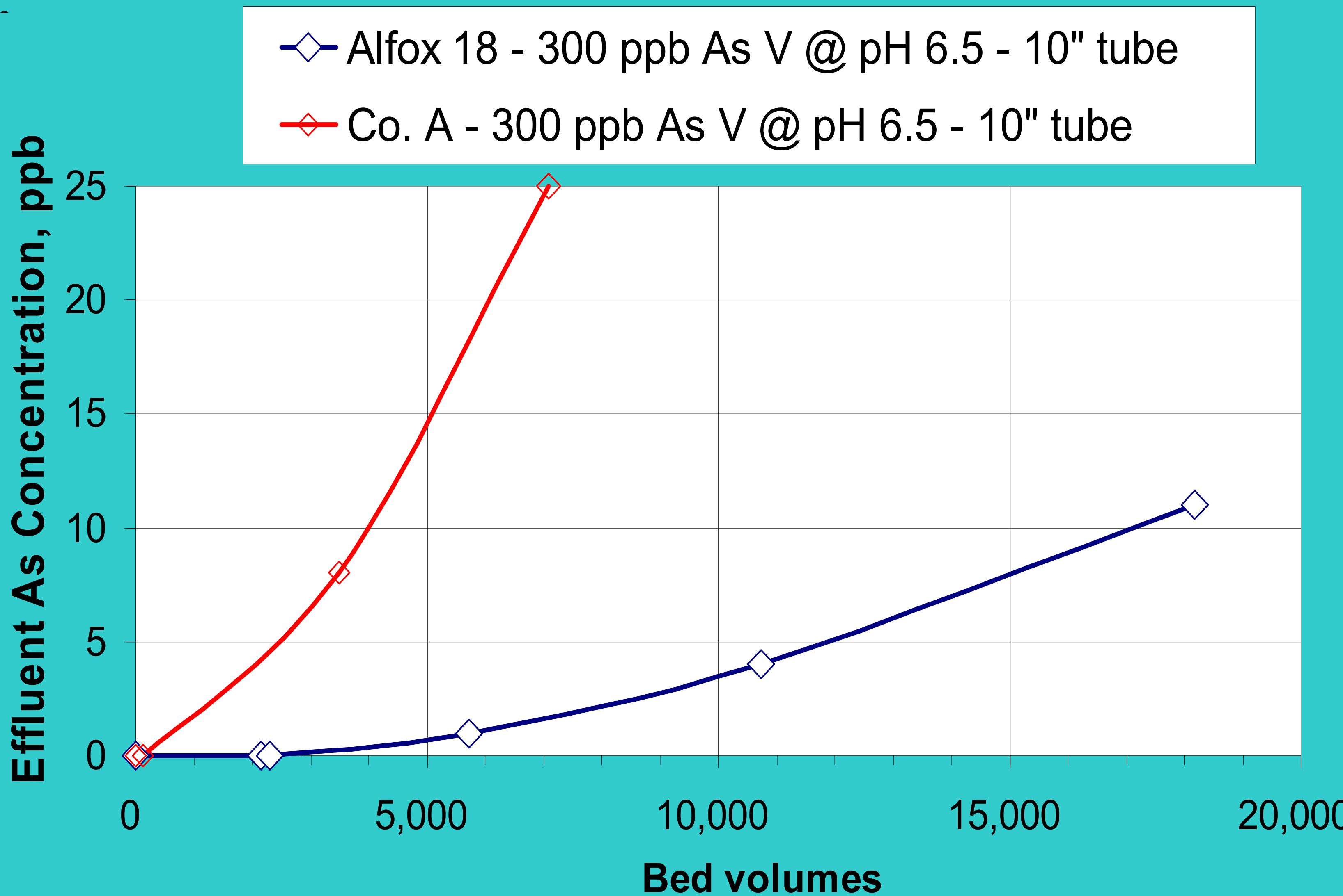


Dynamic Adsorption of 50 ppb As V @ pH8.5



Dynamic Adsorption of 300 ppb As V

Alfox 18 vs Company A (pH 6.5-10” tube)



Langmuir Isotherm

$q = q_m \cdot b \cdot c/(1+b \cdot c)$

where:

q = mass of adsorbate adsorbed per unit mass of adsorbent,

q_m = the maximum adsorbed phase concentration where all the adsorption sites are occupied.

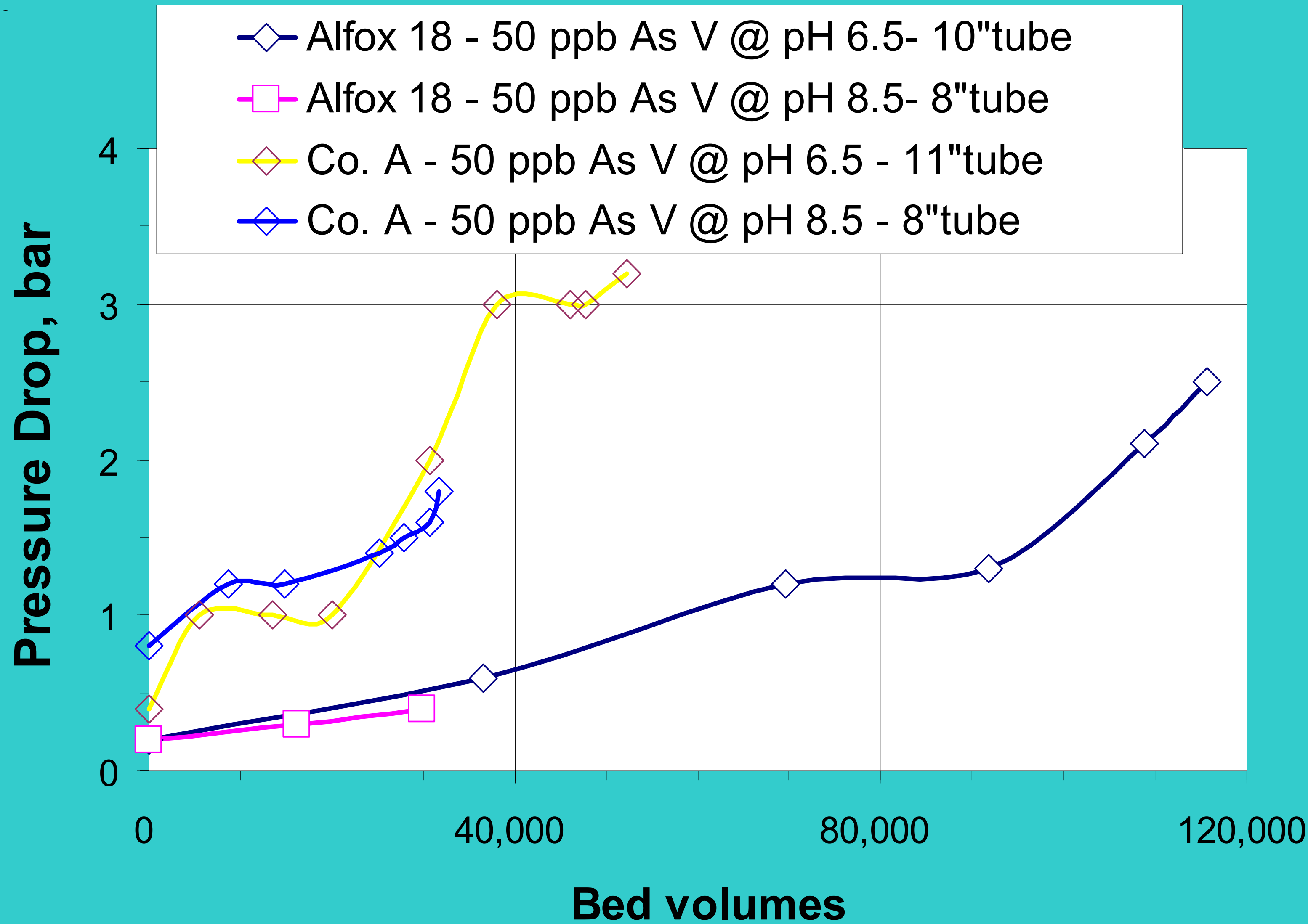
c - solute concentration, in ppb

For As V adsorptions by Alfox-18 coefficients are:

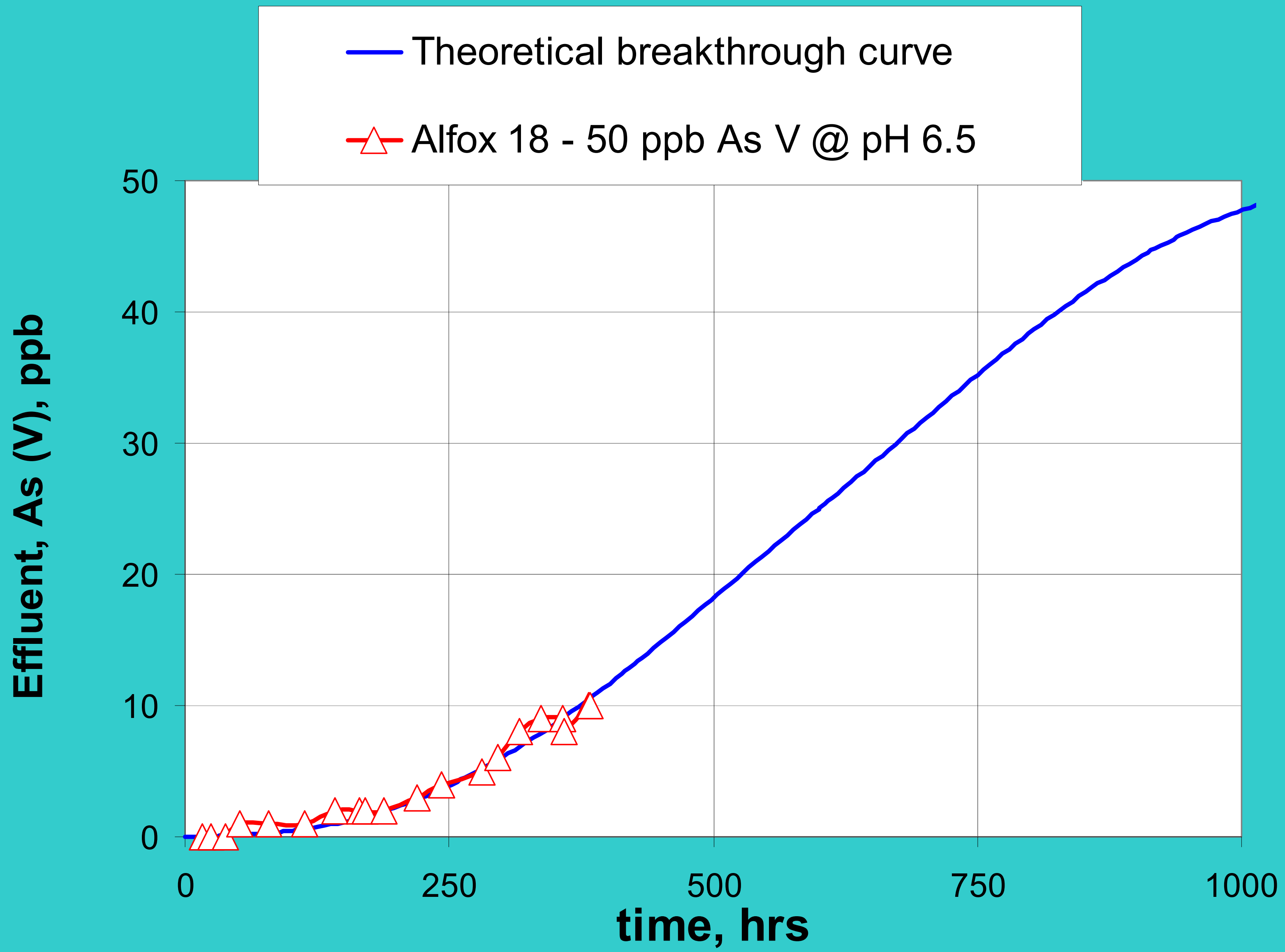
$b = 0.015\ ppb^{-1}$

q_m =27.8 mg As V/g sorbent

Pressure Drop Build-up in Flowing Beds- Co. A vs Alfox 18



COMPARISON OF MODEL



PROJECTED CAPACITY FOR POU
(2.5” Diameter X 10” long bed, 750 g)

Sorbent	Valence	Concentration (ppb)	pH	Capacity to 10 ppb, gallons
Alfox 18	As (V)	50	6.5	20,000
			8.5	6,800
		300	6.5	1,300
			8.5	300
	As (III)	50	6.5	8,300
			8.5	9800
		300	6.5	600
			8.5	500
Alfox GR3	As (V)	50	6.5	42,500
			8.5	20,000

FEATURES AND BENEFITS

- SUPERIOR DYNAMIC ADSORPTION, PARTICULARLY AT pH 6.5
- NO (OR WEAK) DEPENDENCE ON PHOSPHATE AT CONCENTRATIONS LESS THAN 40 ppb PO_4
- BETTER EROSION RESISTANCE
- PREDICTABLE ADSORPTION PERFORMANCE
- ADSORBS SUBSTANTIAL (99.5%) OF VIRUS
- ADSORBS TURBIDITY (from 1.0 to 0.01 NTU)